AN INTEGRATION AREA, SYSTEM AND METHOD FOR PROVIDING INTERCONNECTIONS AMONG COMPONENTS

FIELD OF THE INVENTION

The invention relates to integration areas that provide interconnections among components and, in particular, integration areas that separate the conductive path between components from the integration connections between components.

BACKGROUND OF THE INVENTION

Connections among components typically perform two functions: (1) provide a conductive path between components and (2) provide pin-to-pin integration between connectors. The conductive paths are generally provided by conventional wire and cables that extend between components and/or other connection receptacles, while the pint-to-pin integration generally refers to the manner in which the individual wires or other conductive paths that extend from the respective components interconnect with one another.

Thus, if a system includes very many components to be interconnected, the wires and cables and their routing and interconnections quickly become complex and cumbersome. For example, in the aircraft industry, the same wire bundles may include pin-to-pin connections between line replaceable units (LRUs), such as wire 7 of bundle W123 and wire 5 of bundle W456, and connections between the LRUs and disconnect brackets, such as wire 6 of bundle W123 and wire 2 of bundle W456, as shown in Figure 1. In addition, these bundles may also contain wires that provide connections between various remote portions of the aircraft and wires that provide connections between various local racks and/or shelves within the racks (not shown). Thus, if a change in the configuration of the connections between the LRUs, the LRUS and the disconnect brackets, the remote portions of the aircraft and/or the racks and/or shelves is desired, it is very complicated and time consuming to determine which wires must be manipulated.

Aircraft wiring is further complicated because many of the wire bundle assemblies are unique to a particular aircraft. Thus, there is a lot of variability in the

wiring configuration among aircraft such that the wiring of each aircraft must be customized to the particular aircraft and cannot be automated. The wiring, therefore, is not only very complicated to modify, but also very complicated to initially design and install.

To address the problems created by the complicated wire bundles, integration areas have been developed. These integration areas provide for the desired pin-to-pin interconnections between the individual wires or other conductive paths that extend from the respective components, thereby simplifying the wiring or other conductive paths that extend from the components since it need not be rerouted to accomplish the desired pin-to-pin interconnection.

The conventional integration areas attempt to segregate the wire bundles by separation codes, such that only certain types of connections are included in each wire bundle. For example, connections between the LRUs would be included in one type of wire bundle(s), and connections between the LRUs and disconnect brackets may be included in another type of wire bundle(s). While the conventional integration areas provide assistance in determining the type of wire in each bundle, the conventional integration areas are still very complicated to design and install because all of the wiring continues to be unique to each aircraft and, therefore, must be customized to the particular aircraft.

Thus, there is a need in the aircraft and other industries for wiring integration areas that provide an efficient technique for separating the conductive path between components and the pin-to-pin interconnections that are required between components, but that does not require customized wiring design and installation. In addition, there is a need for integration areas that may be easily modified after installation.

BRIEF SUMMARY OF THE INVENTION

The present invention provides an integration area, a system of integration areas and a method for interconnecting a plurality of components. The techniques of the present invention efficiently separate the conductive path between components from the pin-to-pin interconnections that are required between components by creating an integration area where pin-to-pin integration takes place via connections within and between conductive elements. Because of the nature of the conductive

elements, the connections between the conductive elements may be made automatically based upon a particular configuration for the integration area. In addition, the connections within the integration area may be easily changed, if needed.

The integration area includes component connection receptacles, first conductive elements that extend from each component connection receptacle, second conductive elements that extend across at least one first conductive element, and connections between the first and second conductive elements. The conductive elements include an insulative portion and multiple conductive portions. For example, in one embodiment, the conductive elements may include flatwire segments and/or printed circuit boards. In further embodiments, the component connection receptacles may be connector shells and inserts, and in these embodiments, each first conductive element may be connected to an insert at one end.

The connections between the conductive elements may be made using a variety of techniques. In one embodiment, the connections include pins between respective conductive elements and jumpers that connect at least two of the pins. In another embodiment, the connections between conductive elements include connection vias between respective conductive elements and solder patches that connect at least two of the connection vias.

In further embodiments, the connections include an insulation barrier between the conductive elements, and the insulation barrier defines at least one opening through which the conductive elements connect. In this embodiment, the opening(s) may be filled with a conductive material, such as solder or a conductive pin may extend through at least one of the openings to connect the conductive elements. Other types of connections between the conductive elements may include a fluid insulation material between the conductive elements that may be displaced at points of connection between the respective conductive elements, in some embodiments of the integration area. In other embodiments, the connections may include connection vias between the respective conductive elements that provide connections at all connection points between the conductive elements. Openings may then be defined at the points of connection where connections between the respective conductive elements are undesirable.

Other embodiments include openings defined in the first and second conductive elements, and the openings are at least partially plated with a conductive

material. As such, the conductive material contacts at least one conductive portion of each of the first and second conductive elements such that connections between the first and second conductive elements may be made by at least one conductive pin that extends through respective openings in the first and second conductive elements. In this embodiment, an insulation barrier may be located between the first and second conductive elements to prevent the conductive material of the plated openings in one of the first and second conductive elements from contacting the conductive material of the plated openings in the other of the first and second conductive elements. Thus, the insulation barrier also defines at least one opening aligned with respective openings in the first and second conductive elements. Another embodiment includes an array of spring-loaded pins located between the first and second conductive elements. In this embodiment, the pins are in contact with at least one of the conductive portions of one of the first and second conductive elements. This embodiment also may include an insulation barrier between the array and the other of the first and second conductive elements, where the insulation barrier defines openings where a connection between the first and second conductive elements is desired by allowing a respective pin to extend through a respective opening in the insulation barrier.

The system of integration areas of the present invention includes at least two integration areas as described above, and first and second backplanes that each include at least third and fourth conductive elements. The system also includes connection elements between the first and second backplanes. In one embodiment of the present invention, the connection elements may include single wire, coaxial cables, twisted pair wires, and/or flatwire. The integration areas of various embodiments of the system may include any of the connections between the conductive elements and/or within a backplane as described above. In some embodiments, the conductive elements may include flatwire segments and/or printed circuit boards.

In the method of interconnecting a plurality of components within a set of components, first conductive elements are provided, second conductive elements are positioned across at least one first conductive element, and the first and second conductive elements are connected at multiple connection points. In further embodiments, at least third and fourth conductive elements may be connected within

the backplane at a second plurality of connection points. The first conductive elements may extend between each component connection receptacle associated with components within a set of components and the backplane. The connections between the respective conductive elements may be made by overlapping conductive portions of the respective conductive elements.

In some embodiments of the method, a configuration of connections within and among the components may be received and the connections at multiple connection points of the conductive elements may be automatically made based upon the configuration. In further embodiments, the backplane associated with one set of components may be connected directly to the backplane associated with another set of components or each backplane associated with a set of components may be connected to a second backplane. If a second backplane is utilized, then at least third and fourth conductive elements within the second backplane may be connected at third connection points. Again, conductive portions of the respective conductive elements may be overlapped to connect the conductive elements.

To connect the conductive elements, pins may be provided between the respective conductive elements and at least two of the pins may be connected, in one embodiment. In another embodiment, connection vias may be provided between the respective conductive elements and at least two of the connection vias may be connected to connect the conductive elements. In further embodiments, to connect the conductive elements, an insulation barrier defining at least one opening may be provided between the respective conductive elements and the conductive elements may be connected through the openings, in one embodiment. In other embodiments, fluid insulation material may be provided between the respective conductive elements of another embodiment and the fluid insulation material may be displaced at the points of connection.

Thus, the integration areas, system of integration areas and method of interconnecting components of the present invention provide efficient techniques for separating the conductive path between components from the pin-to-pin integration between components through the use of conductive elements that may be interconnected in a variety of manners. The interconnections between the conductive elements provide integration areas that are much less complex and easier to modify than conventional wiring bundles and integration areas.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

Figure 1 is a schematic wiring diagram of conventional wire bundles that provide both the pin-to-pin interconnections between components and the conductive path between components;

Figure 2 illustrates a partially exploded view of integration areas that provide interconnections within and between connector inserts, according to one embodiment of the present invention;

Figure 3 is a perspective view of integration areas that provide interconnections within and between connector inserts, according to one embodiment of the present invention;

Figure 4 is a perspective view of integration areas that provide interconnections among multiple components, according to one embodiment of the present invention;

Figure 5 is a perspective view of an integration area including pins and jumpers to make connections between the conductive elements, according to one embodiment of the present invention;

Figure 6 is a perspective view of an integration area including connection vias and solder patches to make connections between the conductive elements, according to one embodiment of the present invention;

Figures 7A and 7B are a perspective view and a side view, respectively, of an integration area including an insulation barrier defining openings through which the conductive elements connect, according to one embodiment of the present invention;

Figures 8A and 8B are a perspective view and a side view, respectively, of an integration area including an insulation barrier defining openings filled with a conductive material through which the conductive elements connect, according to one embodiment of the present invention;

Figure 9 is a side view of an integration area including an insulative coating on one of the conductive elements that is locally removed where the conductive elements connect, according to one embodiment of the present invention;

Figures 10A and 10B are a side views of an integration area including a fluid insulation material between the conductive elements that may be displaced where the conductive elements connect, according to one embodiment of the present invention;

Figure 11 is a side view of an integration area including three conductive elements through which conductive pins extend to connect the appropriate conductive elements, according to one embodiment of the present invention;

Figures 12A and 12B are a perspective view and a partial top view, respectively, of an integration area including connection vias providing interconnections at all connection points between the conductive elements with openings defined in both conductive elements where connections are undesired, according to one embodiment of the present invention;

Figures 13A and 13B are side views of integration areas including cavities containing conductive material at all connection points between the conductive elements that may be closed to provide connections between the conductive elements, according to one embodiment of the present invention;

Figure 14 is an exploded view of an integration area that provides connections between the conductive elements at desired locations utilizing a spring array, according to one embodiment of the present invention;

Figures 15A-15E are various embodiments of conductive pins that provide connections between conductive elements; and

Figure 16 is a side view of an integration area that provides connections between the conductive elements at desired location utilizing conductive pins, according to one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present inventions now will be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the invention are shown. Indeed, these inventions may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will satisfy applicable legal requirements. Like numbers refer to like elements throughout.

The present invention provides integration areas, a system of integration areas and a method for interconnecting a plurality of components. The techniques of the

present invention efficiently separate the conductive path between components from the pin-to-pin interconnections that are required within and between components by creating an integration area where pin-to-pin integration takes place via connections between conductive elements. Because of the nature of the conductive elements, the connections between the conductive elements may be made automatically based upon a particular configuration for the integration area. In addition, the connections within the integration area may be easily changed, if needed.

Figure 2 illustrates a partially exploded view of one embodiment of a system **20** of integration areas. In general, the integration areas may be utilized to interconnect a plurality of components. In the embodiment shown in Figure 2, the components (not shown) may be positioned in trays **22**. The components may be any type that require interconnections within or between the components, such as an equipment box or line replaceable unit used in the aircraft industry. The components include multiple pins extending from one side of the component that are typically arranged in various groupings depending upon the type of component. For example, many line replaceable units include three groupings of pins and each grouping may have a different number and/or arrangement of pins. The trays **22** are typically located on a shelf **24**, but may stand-alone or may be located on any other type of support structure known to those skilled in the art. The trays **22** may define openings **26** in which connector shells **28** may be located. Connector shells **28** are, therefore, located within openings **26** and abut the side of the component from which the pins extend. The connector shells **28** also define openings that typically have a shape similar to the pin groupings of the component. As such, the pins may extend through the openings in the connector shell **28**. Any type of connector shell known to those skilled in the art may be utilized. For example, in one embodiment, the connector shell may be an ARINC 600 connector shell, commercially available from ARINC, Inc.

The openings in the connector shells **28** also may receive connector inserts **30**. The connector inserts **30** receive the pins of the component on one side and connect to first conductive elements on the other side. The connector inserts **30** may be any type known to those skilled in the art, such as any of the family of ARINC 600 connector inserts, commercially available from ARINC, Inc. The connector inserts **30**, therefore, are conductively connected to the pins on the side of the insert facing the

component and are conductively connected to one or more of the first conductive elements on another side of the insert. Thus, the connector inserts **30** provide the interface between the component and the conductive elements.

In one embodiment of the present invention, the first conductive elements **32** include an insulative portion and a plurality of conductive portions, such as flatwire, i.e. flex circuit, segments. As such, the connector inserts **30** may be conductively connected to one or more flatwire segment. The connections between connector inserts **30** and such conductive elements are the subject of U.S. Patent Application Number ____________, entitled "Electrical Connector Insert and Apparatus and Associated Fabrication Method", which is incorporated herein in its entirety by reference.

To make interconnections with a component, an integration area **34** may be utilized to interconnect the pins of the component. In the embodiment illustrated in Figure 2, integration area **34** includes first conductive element(s) **32** extending from at least one connector insert **30** in a connector shell **28** and a second conductive element **36** extending across the first conductive element(s) **32**. The second conductive element may be the same type as the first conductive elements. For example, the second conductive element may also include an insulative portion and multiple conductive portions. The conductive portions may also be called conductive traces herein. Typically, the conductive portions are substantially parallel strips carried by the insulative portion. Thus, when the second conductive element extends across the first conductive element(s), the conductive portions of one of the first and second conductive elements cross, typically in a substantially perpendicular manner, the conductive portions of the other of the first and second conductive elements. In one embodiment, the conductive elements may be flatwire, i.e., flex circuit, segments. In other embodiments, the conductive elements may be printed circuit boards or any other type of element with conductive portions carried by or separated by an insulative portion. Connections between the first and second conductive elements may be made in any manner known to those skilled in the art, but specific embodiments of the connections between the first and second conductive elements are discussed below.

As shown in the embodiment illustrated in Figure 2, an end of the first conductive element **32** that is not connected to the connector insert **30** may be

connected to a backplane **38**. In the embodiment shown in Figure 2, the backplane **38** includes an integration area **40** where connections between at least some of the components located on the same shelf **24** and/or tray **22** may be made. The backplane **38**, therefore, may include at least third and fourth conductive elements, each having conductive portions carried by an insulative portion, as described above with respect to the first and second conductive elements **32, 36**. Thus, as described above, the third and fourth conductive elements may also be flatwire, i.e. flex circuit, segments and/or printed circuit boards, in specific embodiments of the present invention. As such, the conductive portions of one of a third conductive element cross, typically in a substantially perpendicular manner, the conductive portions of an adjacent fourth conductive element. If the backplane includes additional conductive elements, then the orientation of the adjacent conductive portions may alternate to create substantially perpendicular conductive portions between each pair of adjacent conductive elements.

The first conductive elements **32** are connected to the backplane **38** in any manner known to those skilled in the art. For example, as shown in the embodiment illustrated in Figure 3, the first conductive elements **32** may be connected to the backplane **38** via standard connectors **42**, such as the FF12 series printed circuit board connectors, commercially available from DDK, Ltd. Thus, any type of connections between the components to which the first conductive elements **32** are connected may be made in the integration area **40** of the backplane **38**. The embodiment of Figure 3, therefore, illustrates an embodiment of the integration area **34** between the connector inserts and the backplane, the integration area **40** of the backplane, and how the first and second conductive elements **32, 36** are connected to the backplane **38**.

In the embodiments of the present invention illustrated in Figures 2 and 3, any signals transmitted by a component carried by the shelf **24** and/or trays **22** are transmitted through the backplane **38** to connectors **44**, as shown in the embodiment of Figure 2. Connectors **44** may be any type of connector known to those skilled in the art, such as connectors similar to EPX B rectangular multi-purpose connectors, commercially available from Radiall. Connectors **44** typically connect the backplane to a connection element that transmits signals from the backplane to another desired location. Any type of connection element may be utilized to carry the signals to the desired location. For example, the connection elements may be single wire, coaxial

cables, twisted-pair wires, flatwire/flex circuit, and/or any other type of connection element.

Figure 4 illustrates one embodiment of the connections between the backplane **38** associated with an equipment shelf **24** and/or trays **22** and other components via connectors **44** and connection elements **46**, 48. In this embodiment, the equipment shelves **24** may be located in an equipment rack **50**. Thus, in an aircraft embodiment, some of the connection elements **46** may transmit signals to another portion of the aircraft, such as another equipment shelf in another equipment rack by connecting directly to another backplane in another equipment rack and/or to any other area where the signals transmitted from the backplane **38** are desired. The embodiment of Figure 4 also illustrates that others of the connection elements **48** may transmit signals from the backplane **38** to a second backplane **52**. The second backplane **52**, therefore may include connectors **54** to which the connection elements **48** connect to provide the desired signals to the appropriate sections of the second backplane **52**.

In the same way that backplanes **38** have integration areas **40**, so does the second backplane **52**. Thus, the second backplane may have integration area **56** that may include the same elements as described with respect to backplane **38**. As such, any type of connection between or among the components on various shelves **24** may be made in integration area **56** of second backplane **52**.

Further integration areas may be located at any other area where further interconnections are desired. For example, multiple racks **50** may have an integration area that provides interconnections among components on different racks. In this embodiment, further connection elements may be connected between second backplane **56** and the multiple rack integration area and/or connection elements **46** may connect directly to the multiple rack integration area. Therefore, signals may be transmitted through each integration area or signals may bypass certain integration areas and connect directly to a desired subsequent integration area or directly to the desired component and/or end point.

In one embodiment, the integration areas **34** may be utilized to provide interconnections within and among only the connector inserts **30** associated with a connector shell **28**, integration areas **40** may be utilized to provide interconnections among the components positioned in a certain tray **22** and/or shelf **24**, and integration areas **56** may be utilized to provide interconnections among multiple trays **22** and/or

shelves **24**, such as in a rack **50**. In other embodiments, however, the various integration areas may be utilized to provide any possible interconnections regardless of where the integration area is located and/or to which components the integration areas directly connect.

Although the integration areas described herein refer to equipment racks with shelves that require interconnections, other types of equipment storage facilities may also be interconnected utilizing the integration areas, system of integration areas and methods of providing interconnections of the present invention. For example, the integration areas described herein may also be utilized to provide interconnections among relay panels. Thus, the integration areas would connect to connectors in a relay panel and any interconnections within or between the connectors would occur in the integration area. As described above, further integration areas may be utilized to provide further interconnections for multiple relay panels and/or any other further connection areas.

As illustrated in Figures 2, 3 and 4, the integration areas, system of integration areas and method of providing interconnections of the present invention provide efficient interconnection areas where the pin-to-pin connections within and between components, shelves, racks, etc. may take place while the conductive path between the integration areas, embodied in connection elements, is separate from the interconnections. Thus, the conductive paths are organized and easy to identify, as illustrated in Figure 4, and the integration areas, as described in detail below create interconnections that are also easy to configure and later identify and/or modify, unlike conventional wire bundles.

The integration areas **34**, **40** and **56** may be created by connecting the conductive elements of the integration areas in any manner known to those skilled in the art. In particular, in embodiments of the integration area in which the conductive elements are embodied by printed circuit boards and/or flatwire/flex circuit, connections between the printed circuit boards and/or flatwire/flex circuit may be made in any manner known to those skilled in the art.

As described above, the conductive elements include an insulative portion that carries and separates conductive portions, i.e, conductive traces. The conductive portions are typically substantially parallel to one another, such that two adjacent conductive elements may be oriented such that the respective conductive portions

cross one another, such as by being oriented substantially perpendicular to one another. Thus, as shown in Figures 5-13, one conductive element **58** may be oriented opposite another conductive element **60**. In particular, the conductive traces **62** of conductive element **58** are oriented to cross, such as in a substantially perpendicular manner, the conductive traces **64** of conductive element **60**. Because the conductive traces of at least one of the conductive elements are directly associated with and make electrical contact with particular items, such as pins, inserts, connectors, components, shelves, racks, panels, etc. depending upon the location of the particular integration area in which the conductive element(s) reside, the conductive traces cross the associated traces provide a conductive path for connecting the various items. For example, conductive traces **62** may be connected to particular pins of a component via a connection insert **30**, as described above, and conductive traces **64** may provide a conductive path between the conductive traces **62** and, therefore, the pins once the desired conductive traces are connected.

Examples of techniques for making connections between or among conductive traces are shown in Figures 5-13, but many other techniques for connecting conductive elements may exist and may be utilized for the connections. Figure 5 illustrates one embodiment in which pins **66** provide a conductive path between conductive traces **62** and conductive traces **64**. To provide the desired interconnections, the appropriate adjacent pins **66** are conductively connected via jumpers **68**. This embodiment is typically used when the conductive elements **58, 60** include printed circuit boards, but may be used for other types of conductive elements also.

Figure 6 illustrates another embodiment for connecting conductive elements **58, 60**, which includes connection vias **70** to provide a conductive path between conductive traces **62** and conductive traces **64**. To provide the desired interconnections, the appropriate adjacent connection vias **70** are conductively connected via solder patches **72**. This embodiment is also typically used when the conductive elements **58, 60** include printed circuit boards, but may be used for other types of conductive elements also.

An insulation barrier **74** is utilized in the embodiment of Figures 7A and 7B to separate conductive traces **62** from conductive traces **64**. The insulation barrier **74** may be made of any insulative material known to those skilled in the art, such as

Tefzel® ETFE, commercially available from E. I. Du Pont De Nemours and Company Corporation. To interconnect the conductive elements **58**, **60**, openings **76** are defined in the insulation barrier **74** at the desired connection locations, such that a conductive trace **62** of conductive element **58** may connect to a conductive trace **64** of conductive element **60** through an opening **76**. One technique for connecting the conductive traces through an opening **76** includes the local application of pressure and heat to the conductive elements **58**, **60** at the opening **76** location to connect the desired conductive traces, such as by soldering the desired traces. Another technique may include applying heat and pressure across a larger portion or the entirety of the conductive elements, with interconnections resulting only where openings are defined in the insulation barrier as long as the insulation barrier properties are such that the insulation barrier can withstand the heat and pressure and prevent connections from being made where openings in the insulation barrier do not exist. Any other technique known to those skilled in the art for connecting the conductive traces through an opening **76** may also be utilized.

The embodiment of Figures 8A and 8B also illustrate the insulation barrier **74** between conductive traces **62** and conductive traces **64** in the same way as described with respect to Figures 7A and 7B. The insulation barrier **74** shown in Figures 8A and 8B, however, includes openings that are filled with a conductive material **78** at the locations where connections between conductive traces **62** and conductive traces **64** are desired. Any type of conductive material may be utilized in the openings, such as solder. In one embodiment, buttons of conductive material may be used to fill one or more of the openings, where the buttons may include conductive parts that are shaped to cooperatively snap together through an opening in the insulation barrier. If the conductive buttons or other conductive material that fills the openings contacts the conductive traces, then an interconnection exists, but in other embodiments, the conductive traces must be manipulated to ensure the conductive traces interconnect via the conductive material in the openings. One technique for connecting the conductive traces via the openings filled with conductive material **78** includes the application of pressure and heat to the conductive elements **58**, **60** to connect the conductive traces at the desired locations, such as by soldering the desired traces to the conductive material. The heat and pressure may be applied locally at the location of the conductive material **78** or the heat and pressure may be applied over a larger

section of the conductive elements **58, 60** because the insulation barrier **74** prevents the conductive traces **62, 64** from connecting at any point other than where the openings filled with conductive material are located. Any other technique known to those skilled in the art for connecting the conductive traces through an opening filled with conductive material **78** may also be utilized.

Another embodiment for connecting the conductive traces **62** to conductive traces **64** at only the desired locations includes applying an insulative coating **80** over one of the conductive traces **62** or conductive traces **64**, as shown in Figure 9. The insulative coating **80** then may be removed at locations **82** where connections between the conductive traces **62, 64** are desired. Similar to the embodiment in which openings are defined in an insulation barrier as shown in Figures 7A and 7B, the conductive traces **62, 64** of the embodiment of Figure 9 may be connected at the locations **82** where the insulative coating **80** is removed by the local application of pressure and heat to the conductive elements **58, 60** at locations **82** to connect the desired conductive traces, such as by soldering the desired traces. Any other technique known to those skilled in the art for connecting the conductive traces at locations **82** may also be utilized.

In further embodiments, the insulation barrier between conductive elements **58** and **60** is made of a fluid insulation material **84**, such as a non-conductive gel, compressible foam, powder, etc. For example, an ultraviolet-cured or thermal-cured epoxy, such as that commercially available from Electronic Material, Inc. may be used for the fluid insulation material **84**. Examples of this embodiment are shown in Figures 10A and 10B. One technique for connecting the conductive traces includes the local application of pressure and heat to the conductive elements **58, 60** at a desired location to connect the desired conductive traces, such as by soldering the desired traces, as shown in Figure 10B. When applying the local pressure and heat, the fluid insulation material **84** is displaced at that location and, thus, the desired conductive traces connect. Alternatively or in addition to the displacement of the fluid insulation material **84**, the heat and pressure may compress and/or burn the fluid insulation material away at the point of connection. In some embodiments, once the desired interconnections between the conductive traces have been made, the fluid insulation material may be cured, such as by the application of heat or ultraviolet light or in any other manner known to those skilled in the art. Any other technique known

to those skilled in the art for connecting the conductive traces through fluid insulation material **84** may also be utilized.

Figure 11 illustrates an embodiment in which more than two conductive elements are utilized in an integration area. For example, in addition to conductive elements **58** and **60** as described herein, conductive element **86** is also added. Thus, conductive elements **58** and **86** have conductive traces **62** that are substantially perpendicular to the conductive traces **64** of conductive element **60**. Also, as shown in the embodiment of Figure 11, conductive elements **58** and **86** may be positioned such that conductive traces **62** do not align with one another, such that connections can be made between a conductive trace **62** of conductive element **58** and a conductive trace **64** of conductive element **60** without also connecting a conductive trace **62** of conductive element **86** and vice versa. While most of the integration area embodiments and techniques for interconnections in the integration areas described herein include only two conductive elements, the various embodiments described herein or that are known to those skilled in the art may include more than two conductive elements. In the embodiment of Figure 11, conductive pins **88** are utilized to provide a conduct path between a desired conductive trace **62** and a desired conductive trace **64**. The conductive pins may be made of any type of conductive material known to those skilled in the art, such as gold plated beryllium copper.

One technique for inserting the pins through the conductive elements includes defining aligned openings in the conductive elements at the locations where connections between the conductive traces **62**, **64** are desired. The openings may have a slightly smaller cross-section than the conductive pins **88**. The conductive pins **88** then may be driven into the conductive elements **58**, **60** and **86** via ultrasound driving techniques, as known to those skilled in the art. Alternatively, when the conductive elements are made of a material that melts under the application of heat from an ultrasonic source, such as mylar®, commercially available from E. I. Du Pont De Nemours and Company Corporation, the conductive pins **88** may be driven through the conductive elements **58**, **60** and **86** using ultrasonic heat that melts the material of the conductive elements to allow the conductive pins **88** to be inserted in the conductive elements at the desired locations. Any other technique known to those skilled in the art for connecting the conductive traces with conductive pins **88** may also be utilized.

In a further embodiment for providing interconnections between the conductive traces **62**, **64** of conductive elements **58**, **60**, respectively, each conductive trace **62** may intersect with each conductive trace **64** through the use of connection vias **90** at each point of connection between the conductive traces **62**, **64**, as shown in Figures 12A and 12B. Figure 12B illustrates a top view of the intersections of the conductive traces **62** and **64** by removing the insulative material of conductive element **58** for clarity. In this embodiment, openings **92** may be defined through one or both of the conductive elements **58**, **60** at locations where connections between the conductive traces **62**, **64** are undesirable. Thus, the connection via **92** may be removed, such as by defining an opening **92** or by any other manner known to those skilled in the art, to eliminate undesired interconnections between the conductive traces **62**, **64**.

The embodiments of Figures 13A and 13B illustrate techniques for connecting the conductive traces **62** and **64** with conductive material, such as solder or any other conductive material known to those skilled in the art, that extends between the conductive traces **62** and **64** at the desired locations. For example, in the embodiment of Figure 13A, solder fuse interconnections **94** are located at all possible connection points between the conductive traces **62** and **64**. The cavities in which the solder fuse interconnections **94** are provided may include wicking areas, such that when heat is locally applied to a solder fuse interconnection **94**, the solder becomes molten and flows into the wicking areas of the cavities, which breaks the solder fuse interconnection **94** and becomes an open fuse interconnection **96**. Thus, where interconnections between the conductive traces **62** and the conductive traces **64** are undesired, the particular solder fuse interconnections **94** may be opened by the technique described above, or by any other technique known to those skilled in the art.

Figure 13B illustrates a similar embodiment to that of Figure 13B, but in the embodiment of Figure 13B the conductive traces **62** are not initially connected to the conductive traces **64** because the conductive material, such as solder, in the cavity does not extend fully between the conductive traces **62**, **64**, as shown by the open solder interconnections **98**. Thus, in the embodiment of Figure 13B, at each point of connection between conductive traces **62** and **64**, a cavity between the conductive traces is partially filled with solder, but the solder does not provide a conductive path

between the conductive traces **62**, **64**. In the locations where interconnections are desired between conductive traces **62**, **64**, the conductive material, such as solder, may be locally heated to cause the solder to become molten and flow further into the cavity, such that the solder extends between the conductive elements **62** and **64** to create closed solder interconnections **100**.

Another embodiment of a technique for connecting conductive elements **62** and **64** is illustrated in Figure 14. In this embodiment, conductive element **60** has connectors **44**, as described with respect to Figure 2 above, to attach the integration area to other components. Thus, the connectors **44** include connection elements, such as pins, that connect to at least one conductive trace **64**. Conductive element **58** may also include connectors **44** that connect to at least one conductive trace **62**. In embodiments in which both the conductive elements include connectors **44**, the connectors **44** on one of the conductive elements **58**, **60** may provide input signals to the integration area and the other conductive element **58**, **60** may provide output signals from the integration area. A spring array **102** and an insulation barrier **74** may be located between conductive elements **58** and **60**. The spring array **102** includes multiple spring-loaded conductive pins **106** positioned to extend from one major surface to the other major surface of a layer of non-conductive material **108** such that the conductive pins are capable of connecting various portions of the conductive traces **62**, **64**. For example, in one embodiment, the number of spring-loaded conductive pins **106** equals the number of conductive traces **62** times the number of conductive traces **64** arranged such that each spring-loaded conductive pin **106** connects one conductive trace **62** to one conductive trace **64**.

The insulation barrier **74** therefore defines at least one opening **105** that is aligned with a respective spring-loaded conductive pin **106** that provides a desired connection between a conductive trace **62** and a conductive trace **64**. Thus, the only connections between conductive traces **62** and **64** are located where an opening **105** is aligned with a respective spring-loaded conductive pin **106**. The insulation barrier **74** may be made of any insulative material known to those skilled in the art, such as Tefzel® ETFE, commercially available from E. I. Du Pont De Nemours and Company Corporation.

Gaskets **107** may be located between the various layers of the embodiment of Figure 14 to prevent air and/or contaminants from contacting the conductive traces

62, **64** or any other element of the integration area. The gaskets may be made of any type of material capable of providing a seal between the desired layers of the integration area, such as rubber. In addition, at least one guide pin **109** may attach and align conductive element **58**, conductive element **60**, spring array **102** and insulation barrier **74** as shown in Figure 14 such as by extending from conductive element **58**, through openings **111** in insulation barrier **74** and spring array **102**, to conductive element **60**.

Figures 15A to 15E illustrate various embodiments of the spring-loaded conductive pins **106** that extend through the layer of non-conductive material **108**. In all of the embodiments described below, it is assumed that the end of the conductive pin **106** that is opposite the insulation barrier **74** is in contact with a respective conductive trace and when an opening that is aligned with the location of the conductive pin is defined in the insulation barrier **74**, the conductive pin connects conductive traces **62** and **64** at the desired location.

Figure 15A illustrates one embodiment in which the conductive pin **106** is made of two portions **110** and **112** that each define openings facing one another. A spring **114** with a non-compressed length that is larger than the length of the two openings defined in portions **110** and **112** may be positioned within the openings in portions **110** and **112** such that portions **110** and **112** are slightly separated when the spring is not compressed as shown in Figure 15A. Thus, when spring **114** is compressed, such as when no opening aligned with conductive pin **106** exists in insulation barrier **74**, portions **110** and **112** are closer together than when the spring is not compressed. As such, when an opening that is aligned with conductive pin **106** is defined in insulation barrier **74**, as shown in Figure 15A, the spring **114** is not compressed such that conductive pin **106** extends through the opening in the insulation barrier **74** and connects the desired conductive traces.

The embodiment of the spring-loaded conductive spring **106** shown in Figure 15B operates similar to that of the embodiment of Figure 15A, but instead of being located within openings of portions **110** and **112**, the spring **116** is connected to portion **110** at one end and to portion **112** at the other end. Thus, when the spring **116** is compressed, such as when no opening that is aligned with conductive pin **106** exists in insulation barrier **74**, the portions **110** and **112** are closer together than when the spring **116** is not compress. As such, when an opening that is aligned with conductive

pin **106** is defined in insulation barrier **74**, as shown in Figure 15B, the spring **116** is not compressed such that conductive pin **106** extends through the opening in the insulation barrier **74** and connects the desired conductive traces.

The springs **114** and **116** described in the embodiments of Figures 15A and 15B are typically made of a conductive material to ensure conduction through conductive pin **106**. The springs **114** and **116** of the embodiments of Figures 15A and 15B may be a coil shape or any other shape, size or material known to those skilled in the art that permits a compression when pressure is applied and extension to a resting length when pressure is not applied. For example, the springs **114** and/or **116** may be a conductive Fuzz Button® commercially available from Tecknit.

The embodiment of Figure 15C, therefore, illustrates that conductive pin **106** may be embodied by a spring **118**, such as a conductive Fuzz Button® commercially available from Tecknit, that extends through non-conductive material **108**. Thus, spring **118** is in a compressed state when no opening that is aligned with spring **118** exists in insulation barrier **74**, but extends to its non-compressed state when an opening is defined in insulation barrier **74** that is aligned with spring **118** such that conductive pin **106** extends through the opening in the insulation barrier **74** and connects the conductive traces **62** and **64** at a desired location.

Figure 15D illustrates an embodiment of the conductive pin **106** that is embodied in a staple shape. For instance, a substantially straight conductive pin **106** may be inserted through the layer of non-conductive material **108** with a portion of the conductive pin extending from both major surfaces of the layer of non-conductive material **108**. The extended portions of the conductive pin may then be bent such that the ends of the conductive pin point substantially toward the respective major surface of the layer of non-conductive material **108**. As shown in Figure 15D, the resulting curved ends of the conductive pin **106** may not be in contact with the layer of non-conductive material when in a resting state. When slight pressure is applied to a curved end, however, the curved end may bend slightly until it contacts the non-conductive material **108**, but when the pressure is removed, the curved end may return to its resting state, which is further away from the layer of non-conductive material **108** than the curved end in the compressed state. Thus, conductive pin **106** is in a compressed state when no opening that is aligned with a respective curved end of conductive pin **106** exists in insulation barrier **74**, but extends to its non-compressed

state when an opening is defined in insulation barrier **74** that is aligned with the curved end of conductive pin **106** such that the curved end extends through the opening in the insulation barrier **74** and connects the conductive traces **62** and **64** at a desired location.

The embodiment of Figure 15E illustrates a further embodiment of conductive pin **106** that includes a connection via **120** that extends through non-conductive material **108** and connects to spring portions **122** on either side of non-conductive material **108**. The spring portions **122** may be connected to the connection via **120** in any manner known to those skilled in the art. For instance, the spring portions **122** may be soldered to the connection via **120**. Thus, one of the spring portions **122** is in contact with a respective conductive trace **62, 64** while the other spring portion **122** is compressed by the insulation barrier **74** when no opening aligned with the respective spring portion **122** exists in the insulation barrier **74**. As such, when an opening that is aligned with the respective spring portion **122** is defined in insulation barrier **74**, the spring portion **122** is not compressed such that conductive pin **106** extends through the opening in the insulation barrier **74** and connects the desired conductive traces.

Figure 16 illustrates another embodiment of a technique for connecting conductive elements **62** and **64**. In this embodiment, the conductive elements **58** and **60**, which may be printed circuit boards, define multiple plated holes **124**. Each conductive trace **62** and **64** is connected to the plating of at least one plated hole **124**. The plating may be made of any type of conductive material known to those skilled in the art. In addition, the plating may be applied or attached to at least a portion of the inner surface of the holes defined in conductive elements **58** and **60** in any manner known to those skilled in the art, such as by coating at least a portion of the inner surface of the holes with a conductive material.

The conductive elements **58** and **60** may therefore be arranged such that the conductive traces **62** and **64**, respectively, are at least substantially perpendicular to one another and the plated holes **124** in one conductive element are at least substantially aligned with the plated holes **124** in the other conductive element. To ensure alignment of the plated holes **124**, the conductive elements **58** and **60** may define openings, such as at one or more of the edges of the conductive elements to accept a guide pin **126**. Thus, when the guide pin **126** is inserted in the respective openings in the conductive elements **58** and **60**, each plated hole **124** in one of the

conductive elements aligns with another plated hole **124** in the other conductive element. An insulation barrier **74** may be located between conductive elements **58** and **60** to prevent contact between the plating of the plated holes **124** defined in the conductive elements. Thus, the insulation barrier **74** also defines openings that align with the plated holes **124**.

To connect the desired conductive traces **62** and **64**, conductive pins **128** may be inserted through the respective aligned plated holes **124** defined in conductive elements **58** and **60**, as shown in Figure 16. The conductive pins **128** may be any shape that securely fits within the plated holes and makes contact with the plating. Examples of certain pins that create a gas-tight connection with the plated holes **124** are described in U.S. Patent No. 6,231,354 entitled "System for Modifying Printed Wiring Connections After Installation," the contents of which are incorporated herein in their entirety by reference.

At least the outer major surface of the conductive elements **58** and **60** and the conductive pins **128** may be enclosed by covers **130** that may mechanically secure the conductive pins **128** and prevent contaminants from interfering with the conductive elements or any other portion of the integration area. In addition, gaskets **107**, as described above with respect to Figure 14, may be located between the covers **130** and the respective conductive element to further prevent contaminants from interfering with the conductive elements or any other portion of the integration area, if desired.

Many other techniques for providing interconnections between conductive traces **62** and **64** exist and may be utilized in the integration areas of the present invention. For example, in any of the interconnection embodiments described above or others known to those skilled in the art, interconnections may be provided at each point of interconnection and the interconnections may be removed where interconnections are undesirable. For example, the interconnections may be removed as described with respect to the embodiment of Figures 12A and 12B, the interconnections may be drilled or burned out of at least one of the conductive elements, and/or the interconnections may be removed in any other manner known to those skilled in the art.

Further embodiments may include the use of programmable logic controllers that make the interconnections between conductive traces **62** and **64**, such as by

utilizing connection vias between the conductive traces at each connection point and connecting transistors at each connection via which would activate and deactivate the connection via, and thus the interconnection between the conductive traces, as desired. This embodiment could also be accomplished utilizing EPROM technology, as known to those skilled in the art. In these embodiments, an interconnection configuration could be burned into the programmable logic controller or EPROM initially and new configurations could be burned in later, if modification of the interconnections are desired.

In addition, the interconnections may be made utilizing a conductive metal with slightly raised portions for at least one of the conductive traces **62** and **64**, where the slightly raised portions are located at the connection points between the conductive traces. The conductive traces may be attached on either side of a board with connection vias or any other type of conductive material located at the points of connection between the conductive traces. Where connections between the conductive traces are desired, pressure and heat may be applied to the slightly raised portions of the conductive traces at the desired locations to deform the conductive traces at that location and connect, such as by soldering, the conductive traces to the connection via at the desired point of connection. In further embodiments, instead of applying heat and pressure to the raised portions of the conductive traces, a latching mechanism may be used to mechanically apply pressure to the raised portions, if desired. Thus, each connection point may include a latching mechanism that may be manipulated to apply pressure to the appropriate portion of a conductive trace.

Thus, the embodiments of the interconnection techniques illustrate that the integration areas may be efficiently created by providing the appropriate connections between the desired conductive traces **62**, **64**. As such, the integration areas, system of integration areas and method for interconnecting components may be created or performed, respectively, by a machine that receives appropriate configuration instructions defining the locations of the desired interconnections between the conductive traces **62** and **64**. Therefore, the integration areas do not have to be manually created like conventional integration areas must be, but instead, may be automatically created by a machine with the appropriate configuration instructions.

In addition, the integration areas and/or conductive paths between integration areas and/or other components may be easily modified after installation because the

interconnections in the integration areas and the various conductive paths are easily identified utilizing the techniques of the present invention that clearly show where the existing interconnections are and where other potential interconnections may be located. As such, the integration areas, system of integration areas and methods for interconnecting components are advantageous over the conventional wiring methods and integration areas that are complex and difficult to manipulate after installation.

Many modifications and other embodiments of the inventions set forth herein will come to mind to one skilled in the art to which these inventions pertain having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the inventions are not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.